

P030083/AE/1

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

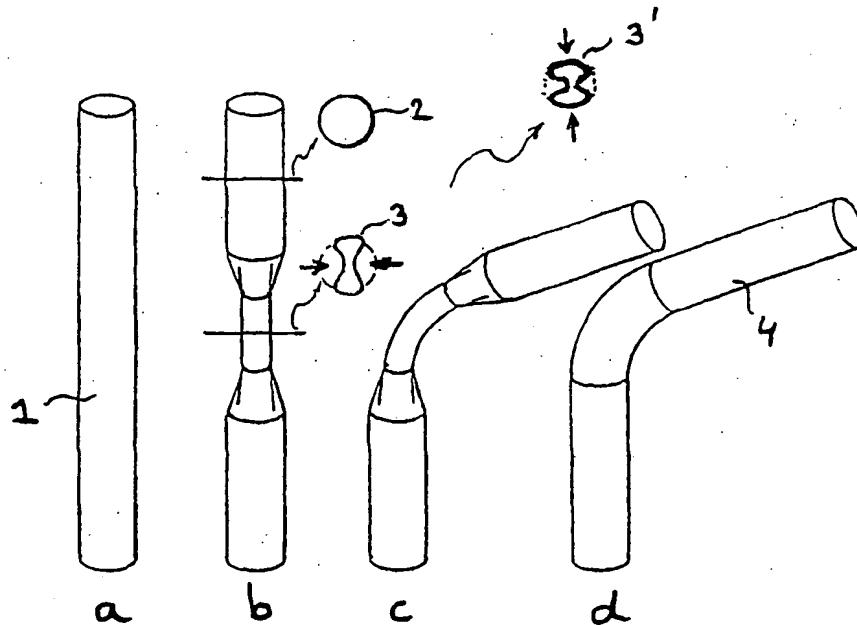
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(S1) International Patent Classification <sup>7</sup> :	A1	(11) International Publication Number:	WO 00/48762
B21D 26/02		(43) International Publication Date:	24 August 2000 (24.08.00)
(21) International Application Number:	PCT/NL00/00099		
(22) International Filing Date:	17 February 2000 (17.02.00)		
(30) Priority Data:	1011330 17 February 1999 (17.02.99) NL		
(71) Applicants (for all designated States except US):	CORUS STAAL BV [NL/NL]; P.O. Box 10000, NL-1970 CA IJmuiden (NL). DR. MELEGHY GMBH & CO. KG [DE/DE]; Werkzeugbau und Presswerk, De-Gasperi-Strasse 8, D-51469 Bergisch Gladbach (DE).		
(72) Inventors; and			
(75) Inventors/Applicants (for US only):	SCHULZE, Bernd [DE/DE]; Chemnitzer Strasse 17, D-09366 Niederdorf (DE). VAN VELDHUIZEN, Hendrik, Bart [NL/NL]; Adigestraat 138, NL-1946 ZK Beverwijk (NL).		
(74) Agent:	HERMAN DE GROOT, Johan, Willem; Corus Technology BV, P.O. Box 10000, NL-1970 CA IJmuiden (NL).		

(54) Title: PROCESS FOR DEFORMING A PIECE OF THIN-WALLED METAL TUBE

## (57) Abstract

Process for deforming a piece of thin-walled metal tube, comprising the operations of bending the piece of tube with respect to its original axis, in which process the wall of the piece of tube is firstly provided, at least at the location where the bend is intended to be, with a deformation which extends substantially in the longitudinal direction of the piece of tube, and in which process wall material is moved closer to the neutral plane of bending, and the piece of tube is then bent, after which the ultimate shape of the piece of tube which is to be deformed is imposed by hydroforming.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## PROCESS FOR DEFORMING A PIECE OF THIN-WALLED METAL TUBE

The invention relates to a process for deforming a piece of thin-walled metal tube, comprising 5 the steps of bending the piece of tube with respect to its original longitudinal axis and then hydroforming the piece of tube at least at the location where it has been bent in this way.

A known method for deforming pieces of tube 10 comprises what is known as hydroforming. In this process, the wall of the piece of tube is pressed against a mould piece under the influence of water pressure, so that the piece of tube acquires its ultimate shape. The hydroforming technique is generally 15 known and therefore does not require any further explanation here. If the piece of tube is also to be bent, a bending operation is carried out prior to and separately from the hydroforming step, in which case the bent piece of tube then acquires its ultimate, 20 desired shape through hydroforming. In this way, numerous very complicated shapes can be produced, which are used in engineering, for example in the automotive industry.

It has been found that, in this processing 25 method, the bending of the piece of tube forms a critical step. Particularly if a small wall thickness is used for the piece of tube, cracks are rapidly formed along the outside of the bend during the bending operation, while wrinkles are formed in the compressed 30 region along the inside of the bend. These wrinkles in this case occur in the circumferential direction of the piece of tube, i.e. they run in a direction which is transverse with respect to the longitudinal axis of the piece of tube. If the bent piece of tube is then 35 subjected to a hydroforming operation, it is found that wrinkles of this nature running in the circumferential direction can no longer be removed. The result is an unacceptable product.

Therefore, the object of the invention is to provide a method in which the production of bent, thin-walled pieces of tube and of products formed using such pieces of tube causes fewer problems. In particular, it 5 is intended to reduce the risk of cracking and to avoid the formation of wrinkles in the circumferential direction.

In the process described in the preamble, this is achieved if the piece of tube, before it is bent, is 10 indented on both the inside and the outside of the bend which is to be formed at the location where it will exhibit a bend as a result of the bending operation.

As a result of the indentation, which involves moving wall material closer to the neutral plane of 15 bending stresses, the piece of tube can be bent more easily, with the result that the risk of cracking and the formation of wrinkles in the circumferential direction is reduced considerably. The ultimate shape of the piece of tube which is to be deformed can then 20 be imposed during the subsequent hydroforming operation, during which any deformations which may have been imposed in the longitudinal direction can be eliminated, or further deformations can be produced. It should be noted that, surprisingly, it has been found 25 that wrinkles in the wall of the bent piece of tube which run in the longitudinal direction, i.e. more or less parallel to the axis of the piece of tube, are no longer visible after the hydroforming has taken place.

The process can be used in order to impart a 30 constant cross section to the deformed piece of tube along its length, in that the undefomed piece of tube is firstly provided with longitudinal wrinkles on either side of the neutral plane as a result of compression, and then, after the bending operation, the 35 constant cross section is restored by the hydroforming step. It has been found that in this way pieces of thin-walled tube with a constant cross section and a relatively small radius of curvature can be produced

successfully. In the past, the production of pieces of tube of this nature caused considerable problems.

In one embodiment of the process according to the invention, the piece of tube, after the indenting step and before and/or after the bending step, is deformed in such a manner that at least part of the material which forms the piece of tube, which part, as seen in cross section through the piece of tube, is situated in a region between regions where the piece of tube is indented, is moved closer to the centre of gravity of the cross section. This further reduces the risk of cracking and/or wrinkling.

The invention will now be explained with reference to a number of figures.

Figs. 1 a-d show the production of a bend piece of constant cross section from a straight piece of tube.

Fig. 2 shows the production of a tubular product of complicated shape from a straight piece of tube.

In Fig. 1, a, b, c and d illustrate various phases of the production of the bend piece 4. In Fig. 1a, reference numeral 1 denotes a straight piece of tube which is to be formed into the bend piece 4 shown in Fig. 1d.

Fig. 1b shows the piece of tube 1 with cross section 2 after the wall has been compressed from either side half-way along the piece of tube, with the result that wall wrinkles are formed in the longitudinal direction. The cross section of the piece of tube at the location of these longitudinal wrinkles is indicated by 3. The arrows which are directed towards one another diagrammatically indicate the indentation according to the invention. Arrows directed towards one another at 3' indicate any further deformation of the piece of tube before or after bending. Fig. 1c shows how the piece of tube can easily be bent at the location of the thinned middle piece, partly as a result of the considerable reduction in the

section modulus of the cross section at that location. The risk of cracks or wrinkles in the circumferential direction occurring is considerably reduced as a result. The shape shown in Fig. 1d can be obtained by 5 subjecting the product shown in Fig. 1c to a hydroforming operation.

Fig. 2 illustrates the production of a workpiece with a more complicated shape. In Figs. 2a1 and a2, a front view of and a cross section through a 10 piece of tube are illustrated. Figs. 2d1 and d2 show a side view of and a cross section through the product 9 formed therefrom. At location 7, longitudinal wrinkles are pressed into the piece of tube 5, with the result that a cross section of the shape of 8 is formed at 15 that location (cf. Figs. 2b1 and b2). The shape shown in Figs. 2c1 and c2 is obtained through bending of the piece of tube.

From this, the final shape 9 can be obtained by 20 hydroforming; numerous variations on this shape are conceivable.

## CLAIMS

1. Process for deforming a piece of thin-walled metal tube, comprising the steps of bending the piece of tube with respect to its original longitudinal axis and then hydroforming the piece of tube at least at the location where it has been bent in this way, in which process the piece of tube, before it is bent, is indented on both the inside and the outside of the bend which is to be formed at the location where it will exhibit a bend as a result of the bending operation.
2. Process according to Claim 1, in which the indenting comprises the step of pressing in wrinkles which run substantially parallel to the longitudinal axis.
3. Process according to Claim 1 or 2, in which the piece of tube, after the indenting step and before and/or after the bending step, is deformed in such a manner that at least part of the material which forms the piece of tube, which part, as seen in cross section through the piece of tube, is situated in a region between regions where the piece of tube is indented, is moved closer to the centre of gravity of the cross section.

Fig. 1

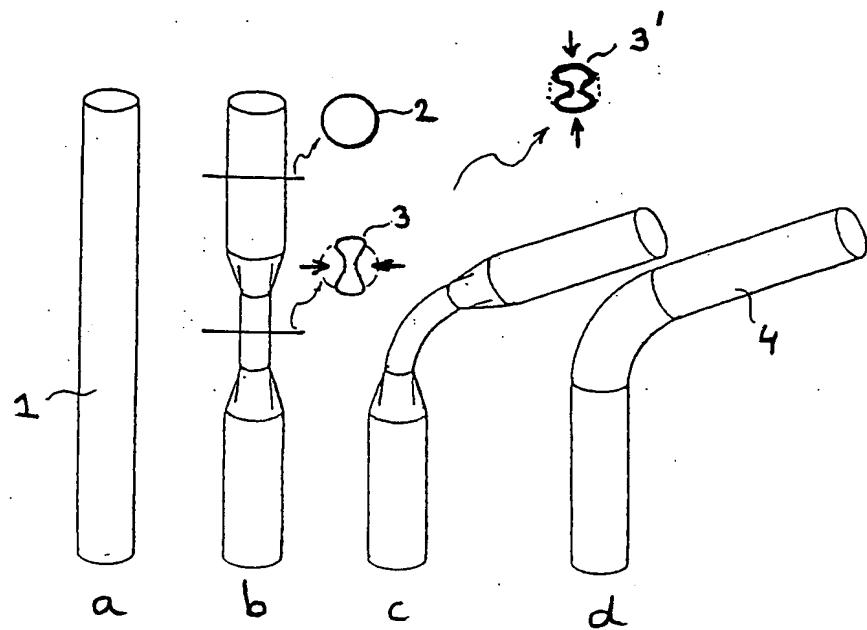
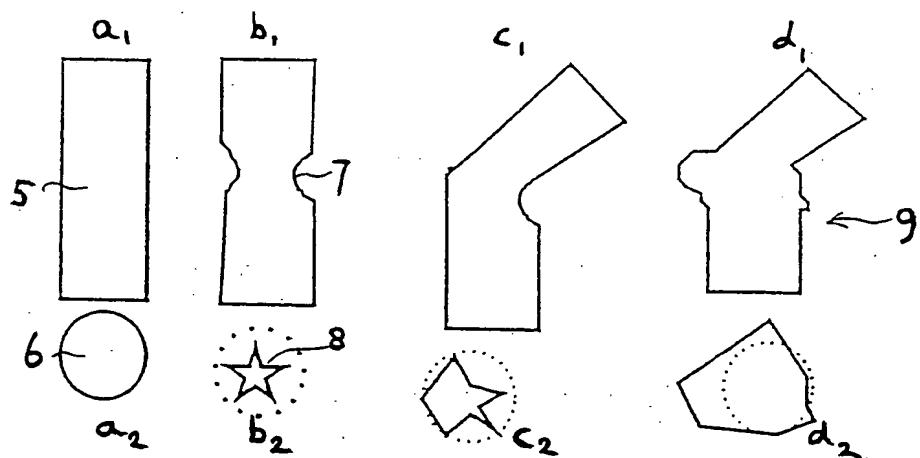


Fig. 2



# INTERNATIONAL SEARCH REPORT

Inte. onal Application No  
PCT/NL 00/00099

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B21D26/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 010, no. 261 (M-514), 5 September 1986 (1986-09-05) & JP 61 086029 A (NISSAN MOTOR CO LTD), 1 May 1986 (1986-05-01) abstract	1-3
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 11, 26 December 1995 (1995-12-26) & JP 07 214147 A (TUBE FORMING:KK), 15 August 1995 (1995-08-15) abstract	1-3
A	DE 44 28 564 A (DAIMLER BENZ AG) 22 June 1995 (1995-06-22)	-/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

27 April 2000

08/05/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

Authorized officer

Peeters, L

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 00/00099

**C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 770 435 A (BENTELER WERKE AG) 2 May 1997 (1997-05-02) --- PATENT ABSTRACTS OF JAPAN vol. 1996, no. 11, 29 November 1996 (1996-11-29) & JP 08 192238 A (TUBE FORMING:KK), 30 July 1996 (1996-07-30) abstract -----	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Application No.

PCT/NL 00/00099

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 61086029 A	01-05-1986	NONE	
JP 07214147 A	15-08-1995	NONE	
DE 4428564 A	22-06-1995	NONE	
EP 0770435 A	02-05-1997	DE 59504498 D ES 2124949 T	21-01-1999 16-02-1999
JP 08192238 A	30-07-1996	NONE	